U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 47.

INSECTS AFFECTING THE COTTON PLANT.

BY

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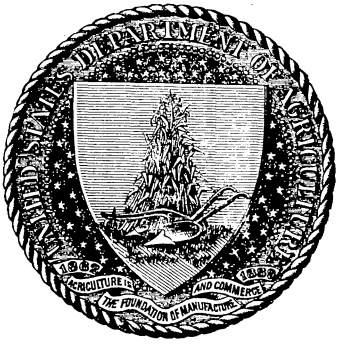
[REPRINTED, WITH REVISION BY THE AUTHOR, FROM BULLETIN 33, OFFICE OF EXPERIMENT STATIONS.]

[January, 1897.]



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1897.

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INSECTS AFFECTING THE COTTON PLANT.

THE COTTON WORM, OR COTTON CATERPILLAR.

(*Aletia argillacea* Hübn.)

GENERAL APPEARANCE, HABITS, AND LIFE HISTORY.

This insect is perfectly familiar to all cotton growers. The slender, bluish-green caterpillar with small black spots, and often with black stripes down its back, which loops when it walks and feeds voraciously on both upper and under surfaces of the cotton leaf, is to be found in cotton fields in the Gulf States all through the summer. It is generally not noticed in the early part of the season on account of its insignificant numbers. Later, through the ragging of the leaves, it becomes noticeable, and in seasons of abundance the plant is entirely defoliated. Farther north the insect makes its appearance at a later date in the season, and there the caterpillars are not the offspring of hibernating moths, but of the moths of the first or second generation, which have developed in more southern cotton fields and have flown north with the prevailing southern winds. Late in the season moths of the fourth or fifth generation fly far to the north, frequently making their appearance in numbers about electric lights in Canada. There is no absolute evidence of any other food plant than cotton, although many entomologists have surmised that the species has a northern food plant. The specimens seen in Canada have, however, in all probability flown north from cotton fields in the Carolinas, and perhaps even farther south.

The egg.—The egg is bluish green in color and of a different shade from that of the leaf, so that it can be rather readily distinguished. It is flattened-convex in shape, with many parallel longitudinal ridges converging at the center above. It is found usually on the under side of the leaves and as a general thing toward the top of the plant. In the neighborhood of 500 eggs are laid by each female, sometimes several upon one leaf, but never in clusters. The eggs are laid at night, since the moth is a night flyer. The duration of the egg state varies somewhat, according to the season. In midsummer the larva hatches in from three to four days after the egg is laid, but in spring and autumn this period is very considerably lengthened.

The larva.—After hatching from the egg, the young larva feeds at first upon the under side of the leaf, devouring simply the lower parenchyma and not piercing through to the upper side until after the first

molt. At first the larva is pale yellow in color, soon becoming greenish. The dark spots become more or less conspicuous after the first molt, and the characteristic markings, as shown in the figure, make their first appearance. After the second molt these markings become more conspicuous, and the insect takes on a distinctly greenish color, the black along the back varying among different individuals in its intensity. Before reaching full growth the caterpillar sheds its skin five times, and the duration of the caterpillar stage is from one to three weeks. Early in the season the green color appears to predominate, while toward the fall the blackish caterpillars are more abundant, although at any time during the season green and dark worms are seen together. Although the normal food of the caterpillar is the leaves, it will frequently gnaw the tender twigs and will even damage the bolls by eating into them in spots. This, however, generally occurs only when the worms are present in exceptional numbers and the supply of leaves becomes exhausted. We have referred to the fact that the caterpillar is a looper, i. e., that it walks by bringing its hind prop legs up to the true legs, causing its back to arch up in a loop. Like the true loopers, or measuring worms, it has the habit of jerking itself some little distance when disturbed, and when it falls it usually supports itself by a silken thread. It is something of a cannibal, and when other food fails, or even rarely when leaves are abundant, it will feed upon smaller and feebler individuals of its own kind. In spite of its comparatively small size and slender form, this larva is, in fact, very voracious, and when occurring in numbers the ruin which it accomplishes is complete.

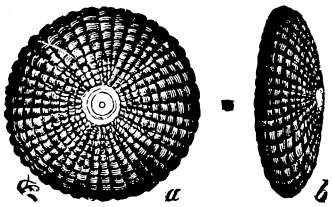

FIG. 1.—Egg of cotton worm moth: *a*, top view; *b*, side view—greatly enlarged (from Fourth Rept. U. S. Entom. Comm.).

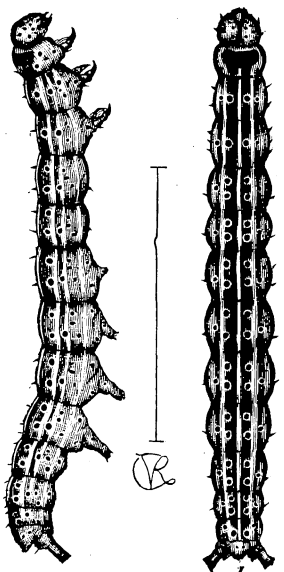

FIG. 2.—Cotton caterpillar: *a*, from side, *b*, from above—twice natural size (from Fourth Rept. U. S. Entom. Comm.).

The chrysalis or pupa.—The caterpillar, having become full grown, never enters the ground to transform, although many planters have believed that this is the manner in which the insect passes the winter. It spins a light silken web, forming an imperfect cocoon, usually within a folded leaf. It is frequently seen hanging quite naked upon the plant, but in such cases the leaf in which it was originally spun has been eaten away by other caterpillars. Its color is at first green, but

in the course of an hour or so it changes to brown. The insect remains in this condition for a period varying from one week to thirty days.

The adult insect.—The perfect insect or imago of the cotton caterpillar is a rather small moth of an olive-gray color, sometimes with a somewhat purplish luster. Its wings expand from $1\frac{1}{8}$ to $1\frac{1}{2}$ inches. The markings of the wings are indicated in the figure. The moth is a night flyer and hides during the day, starting up and flying with a swift, somewhat darting motion when disturbed. After sunset it takes wing and flies about, laying its eggs or searching for food. It feeds, in fact, rather extensively, frequenting neighboring flowering plants and also the nectar glands of the leaves of cotton. Fruit, as it ripens, also attracts these moths, and is frequently seriously injured by them. The tongue or proboscis of the moth is curiously modified and fitted for piercing the skin and tissues of ripe fruit. It is said that they are able to puncture hard green pears, the effect of the puncture being a discoloration of the skin for some distance around. The female begins to lay her eggs in from two to four days after leaving the chrysalis, and each individual lays from 300 to 600 eggs. With five consecutive and rapidly developed generations the occasionally extraordinary numbers of the late broods are not to be wondered at.

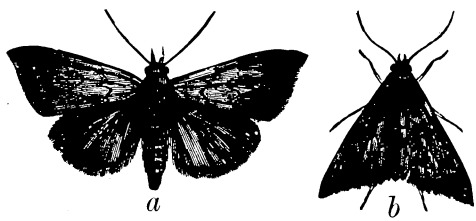

FIG. 3.—Cotton worm moth: *a*, with wings expanded in flight; *b*, wings closed, at rest—natural size (after Riley).

Number of broods or generations.—The observations of Mr. Schwarz in south Texas in 1879 show that at least seven, and probably even more, generations are produced there. Fully as many probably develop in Florida. The general belief in the South up to the time of the beginning of the cotton-worm investigation was that there were three generations only, since three "crops" of worms only were customarily observed. The early generations, however, were overlooked on account of their small numbers, and, in fact, in the northern portions of the cotton belt the general idea was correct enough, since northward-flying moths in general do not oviposit in fields in this region until comparatively late in the season. The moths hibernate only in the extreme southern portions of the cotton belt, as will be shown in the next section, and begin to lay their eggs as early as March, or perhaps even earlier, in south Texas and Florida. Two generations are rapidly developed, and then, in these localities, a confusion of generations commences on account of the retardation of development in certain individuals and acceleration in certain others. Moths from the end of March on are constantly flying out from these points and, carried by the prevailing southerly winds, settle in more northern fields and stock a certain number of plants with eggs. Moths developing from caterpillars hatching from these eggs in turn stock the fields in which they

have developed with a greater number of eggs, and a certain proportion of them fly farther north. In this way there is a progressive development all through the cotton belt and a somewhat varying number of generations in different localities. Under certain conditions, however, such as the early development of a very large brood in the far South, so many moths may be developed that there is a nearly simultaneous stocking of a very extensive region.

The importance of ascertaining the early presence of the worms, although in small numbers, from a remedial point of view, is very great, and since it was conclusively shown that worms may be found in the fields in the Gulf States long before the so-called "first crop," planters have looked for them more carefully, and doubtless in many cases possibly severe injury has been prevented by the poisoning of early worms.

The moths of the last generation in seasons of cotton-worm abundance frequently make their appearance in numbers far north. The moth is a very strong flyer, and, aided by the wind, has been known to occur abundantly in Canada, and has been observed in numbers far out at sea. During September it has been known to do very considerable injury to peaches in Kansas and to ruin acres of cantaloupes as far north as Racine, Wis.

Method of passing the winter.—The greatest difficulty was found in settling the question as to the manner in which this insect passes the winter, but it has finally been established that over the more northern portion of the cotton belt the species dies out every year, while in the more southern portions the moth hibernates and remains torpid in sheltered situations. There must also have been occasionally an ingress of moths from outside of the United States, say from the West Indies or from Mexico or Central America. It was undoubtedly in this way that the species was first introduced into the United States, and such immigrations were probably of frequent occurrence down to comparatively recent years. Professor Riley, writing in 1882, concluded that there is nothing more fully established than that the moth hibernates principally under the shelter of rank wire grass in the more heavily timbered portions of the South, and that these moths begin laying on the rattoon cotton when it is only an inch or so high. Only the exceptional few survive, and this survival seems to be more common in the western part of the cotton belt than in the Atlantic States.

PARASITES AND NATURAL ENEMIES.

In the report by Professor Comstock, published in 1880, and in the Fourth Report of the United States Entomological Commission much space is devoted to the subject of the natural enemies and parasites of the cotton worm. They are very numerous, and without their aid the worms must have done infinitely more damage than they have accomplished; but, practically speaking, we need devote no space to their detailed consideration, as they can not be practically handled. Their increase can not be encouraged beyond the enforcement of gen-

eral laws against the killing of insectivorous birds. Two of the most important of the parasitic insects are shown in the accompanying figures. The little egg parasite, *Trichogramma pretiosa*, a species which is so minute that several specimens live within a single egg of the cotton moth, is one of the more important. Mr. Hubbard has recorded the fact that in Florida this one parasite almost entirely annihilated the fifth brood. At the beginning of the fourth brood about half of the eggs were destroyed by this insect. Of the eggs laid by the fourth-brood moths, from 75 per cent to 90 per cent were parasitized, while of the eggs of the fifth brood the proportion destroyed by the parasite exceeded 90 per cent, and out of the sixth brood careful estimates show that but 3 or 4 eggs out of 100 escaped. The external parasite of the caterpillar, *Euplectrus comstockii* (fig. 4), is also another abundant parasite, while the other insects figured take almost as important parts in limiting the increase of the worm. As far back as 1847 Dr. D. B. Gorham found that nearly all of the chrysalids of the last brood of worms were destroyed by *Pimpla conquisitor* (fig. 5). From this fact he argued that the fields must be restocked by moths flying up from the south, and perhaps from the West Indies. It is a very curious fact that some twenty-five years later Mr. A. R. Grote, studying the cotton worm in Georgia, was unable to find any parasites whatever, and from this fact argued that the insect was not a normal member of the Georgia fauna, but flew in every year, probably from the West Indies.

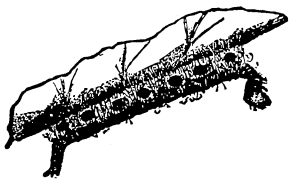

FIG. 4.—Skin of cotton caterpillar attached to the under side of cotton leaf by silk spun about the pupæ of *Euplectrus comstockii* – natural size (from Fourth Rept. U.S. Entom. Comm.).

REMEDIES.

In the Fourth Report of the United States Entomological Commission nearly 200 pages were given to the consideration of remedies and preventive measures. All the false ideas which had gained currency among planters were explained away, an extensive consideration of remedies against the insect in all stages was given, and the subject of machinery for the distribution of wet and dry poisons was most elaborately treated. The chapters on remedies in this report have resulted in great benefit to the agricultural community as a whole. The system of eddy-chamber or cyclone nozzles was here first treated, and modifications of these nozzles are now in active use in all parts of the world for the application of insecticides and fungicides to very many crops. Several elaborate machines for the distribution of wet poisons were invented in the course of the investigation, and all devices which had been patented received consideration. Although, as just stated, this work has been of great value to agriculture and horticulture at large, its results from the standpoint of the cotton grower have, for various reasons, amounted practically to nothing down to the present time.

In 1883 Dr. W. S. Barnard, who had been in charge of the insecticide

machinery portion of the cotton-worm investigation, was sent to Alabama to make field tests of the largest and apparently most practical machines which had been devised. He found that the large machines, so arranged as to underspray sixteen rows of cotton at once, were comparatively impractical, except in a very few cases. Were cotton so planted that the rows were equally spaced the machine would work very well, but the inflexibility of the larger machines prevented them from conforming to inequalities of the ground and to uneven rows. Every cotton planter knows that in an average cotton field the necessities of the case will not allow of ideally true rows. The rows must run wider or narrower according to the quality of the soil and the size of the plant a certain soil will produce. It was found, therefore, that an attempt to underspray more than four rows at once was practically useless.

Such extensive remedial work against this insect as was planned in the Fourth Report of the United States Entomological Commission has not of late been found necessary in the South. Perhaps the main reason is that a change has taken place in Southern agriculture, which has frequently been urged by writers upon economic entomology as most conducive to the limitation of widespread damage by any given species of injurious insect.

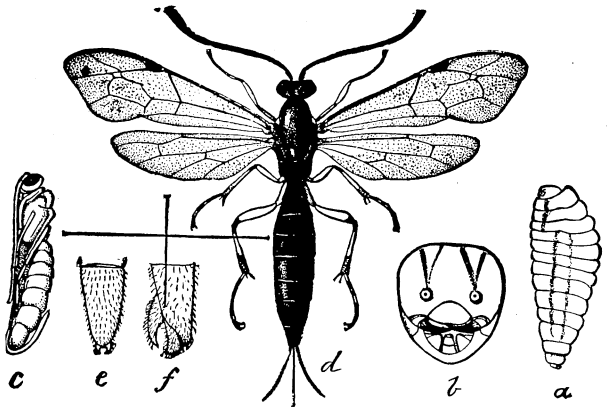

FIG. 5.—*Pimpla conquisitor*, one of the principal parasites of the cotton caterpillar: *a*, larva, enlarged; *b*, head of same, still more enlarged; *c*, pupa; *d*, adult female, enlarged; *e*, *f*, end of abdomen of adult male, still more enlarged (from Fourth Rept. U. S. Entom. Comm.).

This is the greater diversification of crops. Cotton is no longer planted everywhere, as in the broad fields which were so common twenty years and more ago. As a characteristic instance, we may take the case of a prominent planter at Columbus, Tex., who in 1880 had 500 acres of cotton under cultivation in a bend of the Colorado River. In 1894 he had of the same area 300 acres in corn, 100 acres in Johnson grass, and only 100 acres in cotton. It is readily seen that such a breaking up of the immense cotton fields of the South will to a great extent prevent any undue multiplication of the caterpillars and consequent migration northward of the moths. Twenty years ago, moreover, remedial work on a large scale was not attempted by cotton planters. Later the knowledge of the importance of poisoning for the early broods has inspired planters with a feeling of confidence, which has since steadily grown, both as the result of successful remedial work on a more or less small scale and the undoubtedly smaller numbers of the worms.

Further, the development of the cotton-seed oil industry has been an important factor. In earlier times rank-growing varieties of cotton, producing few seeds, but of long fiber, were grown. Now that cotton seed is worth from $9 to $15 a ton, smaller varieties of cotton, with a shorter fiber and a higher proportion of seeds, are more popular. The fields are thus more open, and not only afford a better opportunity for remedial work when necessary, but also show plainly the first "ragging" of the leaves and prevent the worms from working in numbers comparatively out of sight until one or more generations have developed and the moths have become sufficiently numerous to lay eggs for the old and greatly feared "third brood." These points and others have already been reported by Mr. E. A. Schwarz, of this office. His article is a result of observations made upon an official trip through the cotton belt in the summer of 1894. At many points he found the sentiment among planters to be that the cotton-worm question is solved. As a result of these observations and of the reports of Professor Atkinson in Alabama and Professor Tracy in Mississippi, as well as from conversations had with a number of influential cotton planters and correspondence with others, we are quite inclined to believe that the simple method of using undiluted and dry paris green powder which has sprung up throughout the South is probably capable of maintaining present conditions. So far as we know, the large machines recommended in the Fourth Report of the Entomological Commission have never been built and operated by planters.

The distribution of dry paris green from two bags held at the ends of a pole over the back of a horse or mule is a process which has developed apparently spontaneously. At least ten years ago the process was described to the author in a conversation with Hon. Charles E. Hooker, Member of Congress from the Seventh district of Mississippi. Writing in July, 1890, Prof. G. F. Atkinson, of Alabama, spoke of it as a "recent" method. The Mississippi Experiment Station, in June, 1890, described the method as one which had been recently developed. Prof. J. S. Newman, of Auburn, Ala., used the process as early as 1887. It is quite probable, however, that this method dates back to early in the seventies. The method is described by the Mississippi Experiment Station as follows:

Make two sacks of heavy cloth, each about 10 inches long and 4 in diameter, open the whole length of one side and firmly sewed at the ends. We have found 8-ounce osnaburg the best cloth for the purpose. Take a strip of oak or other strong wood about 1½ by 2 inches and 5 feet long, and bore a 1-inch hole 5 inches from each end. Tack one of the sacks to each end of the pole, fastening one of the edges of the opening to each of the narrow sides of the pole.

The sacks can be filled by pouring the poison through a funnel inserted in the holes through the pole, and distributed by riding on horseback through the cotton rows, dusting two rows at a time. A little practice will enable one to do this work very evenly, and care must be taken not to allow the sacks to touch the leaves when wet or the poison will not pass through. When the sacks are freshly filled a very slight jarring will shake out a sufficient amount of the poison, but when nearly

empty the pole should be frequently and sharply struck with a short stick, or spaces in the rows will be missed.

When used in this way we have found it the best plan to use the poison without any admixture of flour, and if flour is to be added lighter cloth should be used in making the sacks.

With a pole and sacks as described, one man and mule can poison from 15 to 20 acres per day.

THE COTTON BOLLWORM.

(*Heliothis armiger* Hübn.)

Unlike the cotton worm, this insect is by no means confined to America, nor is it confined to cotton as a food plant. It is known in many other parts of the world, and it can not be surmised at the present time whether it has been carried from some one point or whether it is indigenous over its extremely wide range. Its food plants vary in an extraordinary degree. In this country it is one of the principal enemies of cotton, of corn, and of the tomato.

The cotton bollworm, the corn earworm, and the tomato fruit worm are all the same species. In addition to these crops, it feeds upon peas and beans, tobacco, pumpkin, squash, okra, and a number of garden flowering plants, such as cultivated geranium, gladiolus, mignonette, as well as a number of wild plants.

GENERAL APPEARANCE, HABITS, AND LIFE HISTORY.

The egg.—The egg is a little larger than that of the cotton worm and more nearly globular. It is nearly white in color but rather inclined to yellowish. Examined with a lens, its sculpturing seems to be almost identical with that of the cotton worm. The eggs are laid upon all parts of the cotton plant, occurring most abundantly on the under side of the leaf. A few can be found upon the stalks, many upon the upper surface of the leaves, some upon the involucre, and occasionally they are seen upon the stems of the boll or upon the petiole of the leaf. The eggs are laid just at twilight, and they hatch in from two days to a week.

The larva.—When first hatched, the bollworm looks much like the cotton worm. It is rather darker in color, but also walks like a looper, or measuring worm. It feeds at first near the eggshell, and then begins to wander away, crawling from one leaf to another, until a young bud or boll is found, into which it bores. Frequently several days pass in this search for a boll, and rarely the worm may reach full growth upon a diet of leaves. It is during this early, wandering, leaf-feeding existence that the insect may be destroyed by arsenical poisons, as is true of the cotton worm. When the young worm enters the flower bud the involucre flares open and the young bud or young boll finally drops. This "shedding" of cotton is, however, not caused by the bollworm alone. Other insects are concerned in the damage, and the flaring and dropping occasionally occurs when no insect injury can be found. A very considerable amount of damage may be done in this way, as a single

FIG. 6.—Transformations of cotton bollworm: 1. Egg on under side of cotton leaf; 2. Larva one-third grown boring into square; 3. Entrance hole of young larva in square, with excremental pellets at edge of hole; 4. Nearly full-grown larva just issued from boll; 5. Full-grown larva on leaf stem; 6. Pupa shown in center of underground earthen cell; cell shown in longitudinal section; 7. Adult moth, light variety; 8. Adult moth with dark fore wings; 9. Adult moth in resting position, wings slightly elevated.

young larva will travel from bud to bud, deserting each before it falls. The bud pierced just before opening is forced into premature bloom, but the worm usually feeds upon the stamens and pistil, rendering it incapable of fructifying. As the bollworms grow, they begin to vary greatly in general appearance. Full-grown worms may be found of almost every intermediate stage of color between light green and dark brown or rose. They may be unstriped and unspotted, or they may possess dark stripes or black spots. These color varieties are not caused by different food, since many variations occur in specimens feeding upon the same plant. Upon cotton the larger worms take the larger bolls, the young ones having confined themselves in the main to the flower buds and the newly formed bolls. They then practically progress downward, the young ones being found mainly upon the top crop, while the older ones bore into the older bolls of the middle crop, the bottom crop being seldom seriously damaged by this insect. Often a single worm will practically destroy several large bolls, and one instance is on record where 18 young bolls and many blooms and unopened flower buds have been destroyed by one not fully grown worm. The bollworm is not only a voracious plant feeder, but it is also a cannibal. Older worms feed upon younger ones, and it has often been known to eat the chrysalids of the cotton caterpillar. With an abundance of vegetable food at hand, the larger worms will seize upon their small brothers, biting through the skin and feeding upon the juices of the body. In ears of corn the remains of several young worms are often found, while the strong, large worm which has destroyed them is the only living occupant of the ear. The larva occupies from two weeks to a month in reaching full growth.

The pupa, or chrysalis.—Unlike the cotton caterpillar, the bollworm enters the ground in order to transform. It forms an oval cell composed of particles of earth held together by a loose, gummy silk, or the pupa may be perfectly naked. It is of a light mahogany color, darker toward the head, and the duration of this state is from one to four weeks.

The adult insect.—The adult insect of the bollworm is a moth about the size of the cotton-worm moth, but has a stouter body and is more extensively marked, as well as more variable in its markings. Its general color varies from a dull ocher-yellow to a dull olive-green. The fore wings have a rather dark band near the tip and the hind wings are also bordered with a darker band. The wing veins are lined with black and the fore wings have also several dark spots. There is great variation in these markings, and they are intensified in some individuals and almost lacking in others. When the moth is at rest, the fore wings are slightly open, whereas in the cotton-worm moth they are closed in a roof-shaped manner. The moth flies normally about dusk, lays about 500 eggs, and is not a fruit feeder like the cotton-worm moth. During the day they hide in cowpeas and in clover, when these grow near the

cotton field, and fly low with a quick darting motion when disturbed. About sunset they begin to feed upon the honey secreted by the cowpea and blossoms of clover, as well as upon the nectar of the cotton plant and other honey-secreting plants. Mr. Mally speaks of seeing the moths eating at 3 o'clock in the afternoon, and Mr. Mullen states that he has noticed them feeding freely during all hours except the early morning hours, and during 1892 noted them particularly depositing their eggs in broad daylight.

Number of generations.—The average time occupied by the insect in its transformations from egg to the adult is about thirty-eight days. The number of annual generations is about five. In the cotton-growing States the worms of the first three generations feed usually in the cornfields. In fact, in choice of food plants, cotton seems to be secondary to corn. They feed upon corn by preference until this becomes too hard to be readily eaten. The worms of the first generation make their appearance the latter part of April or early in May, and feed almost exclusively upon the leaves and terminal buds of corn. The second generation, appearing in early June, feed upon the tassels and forming ears of corn, while the third appears in July and feeds upon the hardening corn. When the fourth generation appears, the corn has become too hard for appropriate food, and the moths therefore fly to neighboring cotton, which carries at that time plenty of tender young bolls. A few worms will have been found upon cotton before this time and will have fed upon the leaves and flower buds only in the absence of bolls. Others will have been found upon tomatoes, if these are grown upon the plantation, while still others have been feeding upon cowpeas. As a general thing, bollworms are seen in force upon cotton about the first of August, and usually these individuals belong to the fourth generation. The fifth generation makes its appearance about the middle of September, and about the middle of October, or even earlier, the caterpillars enter the ground for transformation to pupæ.

Hibernation.—The bulk of the bollworms hibernate in the pupa state underground. In a warm fall the moths have been known to issue during the month of November, and Mr. Mally has shown that frequently a few moths hibernate. These hibernating moths appear and begin laying eggs much earlier than the moths which issue from overwintered pupæ. This results in something of a confusion of generations the following season, and at Shreveport, La., Mr. Mally found a series of small broods along with the more or less regular large ones, a sixth generation of worms appearing a little later in the fall and hibernating in the pupa state. In evidence of this fact he adduces the finding of young bollworms as late as November 20. Young and old worms may, in fact, be found simultaneously after the middle of May. Mr. Mally's observations, however, extended through two seasons only, and this state of affairs may be exceptional, particularly as the winter of 1890–91, when he made his observations, was unusually mild in Louisiana and

the spring earlier than usual. In Arkansas four or five generations are found in the northern and southern portions of the State, while in southern Texas six generations and a partial seventh seems to be the rule. The determination of the time of the appearance of the several generations of moths for each differing locality is of very considerable importance, and can only be made by local observers. It is of importance in arranging for the trap-crop method of protecting cotton, which will be discussed under the head of remedies.

NATURAL ENEMIES.

The bollworm has by no means as many natural enemies as the cotton caterpillar. The latter insect feeds exposed upon the leaves, and is therefore subject to the attacks of predaceous and parasitic insects, as well as birds. The bollworm, however, as a general thing, feeding in the interior of the cotton boll, or ear of corn, or fruit of tomato, or pea or bean pod, is not readily found. In fact, although birds have been noticed to feed upon it, it was long considered to be absolutely free from true parasites. Riley, however, bred a Tachina fly from the larva, and Hubbard reared the little egg parasite *Trichogramma pretiosa* from the bollworm eggs in Florida. The more recent investigations of Mally have resulted in finding four additional parasites. One of these is an egg parasite of the genus Telenomus. Another is a species of Limneria, while the other two are the common *Euplectrus comstockii* How. and *Chalcis ovata* Say, which are such abundant parasites of the cotton worm. The hairy or downy woodpeckers are frequent visitors of cornfields and have been seen to extract the worms from infested ears.

REMEDIES.

Lights for trapping moths.—This is one of the remedies which nave been most often advised, and has been very extensively used in parts of the South, particularly in Texas. In view of this fact, Mally, during his two summers' investigations, made extensive experiments with trap lights for the moths. He has carefully tabulated all the insects which were captured in this way. A few bollworm moths were caught, but these apparently by accident, and a thoroughly unprejudiced conclusion from his experiments must be that the use of lights for attracting and trapping bollworm moths is without beneficial result. The other insects caught by the light were found to be about evenly divided between those which are beneficial and those considered injurious; but most of the insects called injurious are of no especial economic importance in the cotton region and should be omitted from consideration in forming conclusions. The use of lights, from the cotton-grower's standpoint, is really a disadvantage, and money expended in this practice is without doubt entirely lost.

Poisoned sweets.—Together with the use of lanterns for attracting the moths, poisoned sweets have been recommended for many years.

Mally also experimented in this direction and found that a modification of this remedy is more or less effective. He advises the planting of a few rows of cowpeas as a trap bordering the cotton fields. They should be planted so late as not to reach the height of blooming before the destructive August brood appears. A portion of the row should be sprayed over every night with a mixture of 4 ounces of beer to 2 ounces of potassium cyanide solution. The moths will be attracted by this mixture and will be destroyed by it. The mixture dries readily, and hence if applied in the afternoon will not result in the destruction of any day-flying beneficial insects.

Poisoning the worms.—The careful study which has been made of the natural history of the bollworm, particularly that by Dr. William Trelease, in Alabama, in 1880, shows that where arsenical poisons are applied for the so-called third brood of the cotton worm, about August 1, many bollworms are destroyed. It is about this time that many young worms are hatching from the eggs and feeding for a longer or shorter space of time on the leaves before entering the bolls. It was therefore thought at the time when Comstock's report on cotton insects was written that the poisoning for the cotton worm, which was so strongly recommended and which was so necessary under the conditions governing at that period, would largely reduce bollworm injury. In fact, as we have shown in our opening paragraph, the bollworm itself at that time was by no means such a factor in cotton growing as it is at the present time. With the great reduction of damage done by the cotton worm and the great increase of that done by the bollworm, however, poisoning for the cotton worm has become comparatively rare, and on account not only of the greater abundance of bollworms, but also of the consequent greater confusion of generations of this insect, and the fact that not more than half at the outside could be destroyed by poisoning at any one given time, this method has largely lost its former value as a bollworm remedy.

Trap crops.—In the intelligent handling of trap crops the cotton planter will find by far the most efficacious preventive of bollworm damage. This suggestion is an old one. It was proposed by Sorsby in 1855, by E. Sanderson in 1858, and by Peyton King in 1859. It was recommended by Comstock after careful preliminary observations by Trelease in 1879, and Riley in 1885 gives it at least equal rank as a remedy with poisoning. The complete development of the trap-crop system, however, rests upon the studies and recommendations made by Mally; and S. B. Mullen, of Harrisville, Miss., has written in a most practical manner relative to corn. Mally's recommendations are, in brief, when planting cotton leave vacant strips of 5 rows for every 25 of cotton. In these 5 rows, at the earliest possible time, plant 1 row with an early maturing sweet corn. It should not be drilled in too thickly, as a minimum number of plants and ears is desired. During the silking period frequent careful examinations must be made as to the

number of bollworm eggs. As soon as no more fresh white eggs are found each morning, the silk ends of the corn should be cut away and burned or fed to stock in order to destroy the young worms and the eggs. A few eggs may also be found upon the leaves of the plants, and since no more growth is to be made the plants should be cut and destroyed. Then 3 more of the rows should be planted to dent corn at such a time as to bring the silking period about the 1st of July or a little later. Upon these rows very large numbers of eggs will be laid, but they should be allowed to mature in order that the natural enemies which parasitize the eggs and prey upon the larvæ may not be destroyed. The crowded condition of the worms in the ears developed in these 3 rows will induce cannibalism to such an extent that the number of worms reaching maturity will be reduced to the minimum, and these can well be allowed to escape if the natural enemies are saved thereby. To trap these escaping individuals, however, the fifth and last row of the vacant strips should be planted to sweet corn at a time which will allow it to reach full silk about August 1, since the majority of the moths begin issuing again about that time. This last row should be carefully watched, and the corn should be cut and destroyed as soon as it appears that no more eggs are being deposited. Mr. Mally found that the corn produced by the second planting is likely to be large enough in quantity to pay for expense of cultivation and the sacrifice made by cropping the 5 rows in corn instead of cotton. Moreover, he thinks that if the first two plantings are well managed the earlier broods of the bollworm will be so reduced in numbers that the August brood will not be capable of inflicting great injury, and therefore in the less-infested regions the third planting may be dispensed with. He further found that it was not necessary to crop the entire plantation with this 5 to 25 rows of corn to cotton. If 5 acres be planted in this way for every 50 acres of cotton, or even 5 acres of trap alternate for 75 or 100 acres, the crop of the entire plantation may be protected.

THE MEXICAN COTTON-BOLL WEEVIL.

From the present outlook the most important of the insects which damage the cotton boll, next to the bollworm itself, is the cotton-boll weevil (*Anthonomus grandis* Boh.).

GENERAL APPEARANCE AND METHOD OF WORK.

This insect is a small, grayish weevil, of the shape and general appearance shown in fig. 7, *a*, and measuring a little less than a quarter of an inch in length. It is found in the cotton fields throughout the season, puncturing and laying its eggs in the squares and bolls. The larvæ, of the shape and appearance shown at fig. 7, *c*, and measuring a little over three-eighths of an inch in length when full grown, live within the buds and bolls and feed upon their interior substance.

The squares attacked usually drop, but most of the damaged bolls remain upon the plant and become stunted or dwarfed, except late in the season, when they either dry or rot.

DISTRIBUTION.

The insect through its ravages caused the abandonment of cotton culture around Monclova, Mexico, about 1862. Two or three years ago cotton was again planted in that vicinity, but the weevil immediately reappeared and destroyed the crop. At Matamoras the weevil was noticed eight or ten years ago. About 1893 it crossed the Rio Grande at Brownsville, Tex., and in 1894 was noticed in the country around San Diego, Alice, and Beeville. At the close of the season of 1894 the insect occupied a territory extending to the north a little beyond Beeville, a few miles to the east of that point, and southwest to the neighborhood of Realitos, on the National Mexican Railway. The greatest damage seems to have been done along the lower Nueces River. During 1895, and particularly in the latter part of the season, it extended its range to a considerable extent. Toward the east it was found in moderate abundance along the valley of the Guadaloupe River at Victoria, Thomaston, and Cuero. North of its old range it extended to Kenedy, Floresville, and many points in the country lying between the latter place and Cuero. A single field was found near San Antonio which contained weevils in large numbers, and in the same way a single field was found far to the east, at Wharton, in which the weevils had appeared late in the season. The exact localties where the insect was found during 1895 are indicated on the accompanying map (fig. 8).

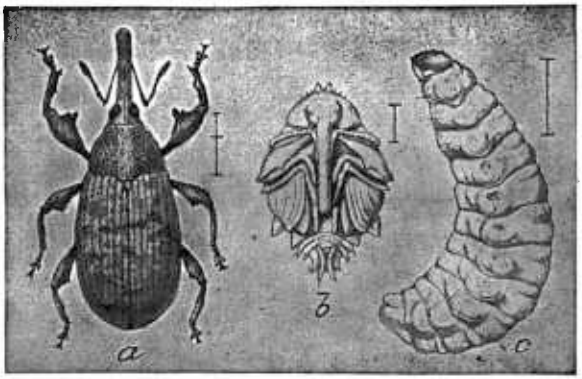

FIG. 7.—The cotton-boll weevil (*Anthonomus grandis*): *a*, adult beetle; *b*, pupa; *c*, larva—enlarged (from Insect Life).

It was feared that during 1896 there would be a further spread of the weevil; but for some reason, probably on account of the severe midsummer drought, there was not only no spread beyond the limits of 1895, but on the contrary a shrinkage of the territory infested. The main spread in 1895 took place in the autumn, and at the outer boundaries, as at San Antonio and Wharton, the weevil was killed by the winter frosts. In 1896 the drought prevented the "make" of the top crop at many points and there was little food for the autumnal generations of the weevil, and therefore a lesser spread from the localities of successful hibernation.

The insect passes the winter in the weevil state. It can be found on the cotton plant until late in December, and, in fact, as long as any portion of the plant is green. It is found most abundantly in the early winter hidden between the involucre and the boll, and later it frequently works its way down into the dry and open bolls. All the specimens found by Mr. Schwarz in such situations in the late spring of 1895 were dead; but Mr. Townsend found a few living in March. The dry boll is probably not a frequently successful hibernating place.

FIG. 8.—Map showing distribution of the Mexican cotton-boll weevil in 1895.

With the cutting of the plants, or with the rotting or drying of the bolls as a result of frost, the adult weevils leave the plant and seek shelter under rubbish at the surface of the ground, or among weeds and trash at the margin of the fields. Here they remain until the warm days of spring, when they fly to the first buds on such volunteer plants as may come up in the neighborhood. They feed on these and lay their eggs on the early squares, and one or perhaps two generations are developed in such situations, the number depending upon the character

of the season and the date of cotton planting. By the time the planted cotton has grown high enough to produce squares the weevils have become more numerous, and those which have developed from the generation on volunteer cotton attack the planted cotton, and through their punctures, either for feeding or egg laying, cause a wholesale shedding of the young squares. It seems to be an almost invariable rule that a square in which a weevil has laid an egg drops to the ground as a result of the work of the larva; in the square on the ground the larva reaches full growth, transforms to pupa, and issues eventually as a beetle, the time occupied in this round approximating four weeks. Later, as the bolls form, the weevils attack them also and lay their eggs in them, and the larvæ develop in the interior just as with the squares. The bolls, however, do not drop. Fig. 9, *a*, and *b*, show the larvæ in the squares, and fig. 9, *c*, shows a young boll cut open and the pupa in its customary position.

FIG. 9.—The cotton-boll weevil: *a*, newly hatched larva in young square; *b*, nearly full-grown larva *in situ*; *c*, pupa in young boll picked from ground (author's illustration).

There is a constant succession of generations from early spring until frost, the weevils becoming constantly more numerous and the larvæ and pupæ as well. A single female will occupy herself with egg laying for a considerable number of days, so that there arises by July an inextricable confusion of generations, and the insect may be found in the field in all stages at the same time. The bolls, as we have just stated, do not drop as do the squares, but gradually become discolored, usually on one side only, and by the time the larvæ become full grown generally crack open at the tip. While in a square one usually finds but a single larva, in a full-grown boll as many as twelve have been found. In any case, however, the hatching of a single larva in a boll results in the destruction of the boll to such an extent that its fiber is useless. Where no serious frost occurs in December, the insects all, or nearly all, reach maturity and enter hibernating quarters, although larvæ have been found even in January at Sharpsburg. Whenever a heavy frost comes in this month, or before, the observations show that those insects which have not reached the beetle stage are nearly all killed. From this fact it follows that the insect will probably not prove as injurious in other portions of the cotton belt as it is in southern Texas.

It was found during the latter part of 1895 that the weevil was present

in a number of localities in which it was not known by the planters themselves to occur. It is important that every planter who lives in or near the region which we have mapped out should be able to discover the weevil as soon as it makes its appearance in his fields. Where a field is at all badly infested, the absence of bloom is an indication of the presence of the insect. In the early part of the season the weevils attack the squares first, and these wilt and drop off. A field may be in full blossom, and as soon as the insect spreads well through it hardly a blossom will be seen. This dropping alone, however, is not a sufficient indication of the weevil's presence. Squares are shed from other causes, but if a sufficient number of fallen squares are cut open the cause will be apparent. The characteristic larva of the weevil will be quite readily recognizable on comparison with the figures which we publish herewith.

As stated above, the bolls do not drop. The punctures made by the weevils in feeding, however, are comparatively characteristic, and

FIG. 10.—Mature boll cut open at left, showing full-grown larva; the one at the right not cut, and showing feeding punctures and oviposition marks (author's illustration).

where a boll is discolored and has begun to crack at the tip the larva or the pupa can be seen without trouble on cutting it open. Late in the season the weevils themselves will be found between the involucre and the boll, as shown in fig. 11; or in their absence the feeding marks and the yellow, granular excrement which collects in the involucre at the base of the boll are excellent indications.

PARASITES AND NATURAL ENEMIES.

It is safe to say that little assistance will be derived from the work of natural enemies and parasites upon this insect. Of the former none of any importance have been found. Several parasites, however, have been found to attack it, and in one or two localities some little good has resulted from their work. They have only been abundant, however, late in the season, after the weevil has completed its damage for the year, and at a time when a minimum of good can be accomplished

by the destruction of the larva. The majority of the weevils in a given field fail to hibernate successfully, being killed by cold weather or some other cause, so that the work of parasites at this time does not count. Careful estimates, however, show that from 15 to 20 per cent of the weevil larvæ in fallen squares in November at Beeville and Kenedy were destroyed by parasites. There is a bare possibility that in the original home of the weevil (south Mexico and some Central American States, as well as certain of the West Indies) more efficacious parasites could be found. Mr. Townsend, however, while on a trip to Yucatan, was not only unable to find parasites, but captured only a single specimen of the weevil itself.

REMEDIES.

In considering the matter of remedies it should be understood at the outset that experience has shown that none of the general applications of insecticides are of the slightest value against this species as a means of protecting infested fields. The weevil in its work in growing cotton is thoroughly protected against poisons, breeding as it does within the blossoms and squares. As demonstrated by the experience of the spring of 1896, poisons may, however, be used as a means of destroying overwintered beetles on volunteer cotton. The beetles which have survived the winter collect in the early spring on the first sprouts which appear on old cotton and eat the partially expanded leaves and the tender leaf stems, and at this stage can be poisoned by the application of an arsenical to this new growth. To do this it will be necessary to thoroughly spray the growing tips, and this should be done when volunteer cotton is very small, preferably mere sprouts or bunches of leaves an inch or two in length; later on the growing parts can not be easily reached. With an ordinary knapsack pump a field may be gone over rapidly and the volunteer cotton thoroughly treated, the nozzle being directed at each growing tip. The first application should be made as soon as the volunteer sprouts, and perhaps repeated two or three times within as many weeks. As ordinarily cultivated, the number of volunteer plants is small and the time required for the thorough spraying of such plants will not be great. A strong solution should be applied, viz, 1 pound of the poison to 50 gallons of water, because no harm will be done if the volunteer plants are ultimately killed by the poison.

FIG. 11.—Late-fall boll, showing how beetles hide between boll and involucre (author's illustration).

The practicability of this method has been demonstrated, but it has been abundantly shown that the very best system of control of the weevil is in a system of cultivation of cotton, to be later described, which will prevent all possibility of volunteer growth whatever. The poisoning and the other palliative measures relative to volunteer growths

are given, therefore, merely as a means of correcting an evil which may result if the cultural system referred to has been neglected. These remarks apply, for instance, to the trap system, which we have hitherto recommended among others. This consists of attracting the earliest beetles to a few cotton plants left at convenient points and protected from winter killing by forced watering, so that they will branch out and acquire buds often in advance of volunteer cotton. From these the beetles may be collected by hand when they are attracted to them by the first warm days, or, preferably, these plants may be poisoned, as already suggested.

The fact that the spring generation develops only upon volunteer cotton has suggested the possibility that the insect will not spread beyond the region where volunteer cotton will grow in spring, but unfortunately this possibility is by no means absolutely to be relied upon. Nevertheless, the destruction of such volunteer plants as come up in cornfields and in abandoned fields which the previous year were planted to cotton, unless they be systematically poisoned, can not be too strongly recommended, for it is a matter of observation that the shade afforded by the corn or the rank-growing weeds which come up in abandoned fields is especially favorable to the development of the weevils.

While the plants are young, and where labor is as cheap as it is in south Texas, a great deal of good can be accomplished by picking and burning the fallen squares, and if this is done promptly a large number of the insects will be destroyed. It should be done at least twice, at intervals of three weeks, during the period while the plants are small. As soon as the plants begin to branch out, however, this method becomes impracticable, on account of the difficulty of finding the squares on the ground.

The idea of picking the affected bolls during the cotton picking was suggested in the writer's first published account of this insect. It was thought that the affected bolls could be so readily recognized that many thousands of the insects could be destroyed by the cotton pickers by picking these affected bolls and carrying them away in a separate receptacle to be burned. The amount of extra labor involved in this operation, however, would be very considerable, and the affected bolls in many instances are not to be recognized at a glance.

During the past year Mr. Stronhall, of Beeville, has devised a machine for jarring the affected squares and blossoms from young cotton plants and collecting them at the same time. This apparatus has been given a partial demonstration the past season and seems to do fair work. It is arranged to brush the cotton from both directions vigorously, and the loosened bolls and squares are caught on receiving trays and ultimately burned or otherwise destroyed. The brushes work in opposite directions and strike the cotton plants on either side. It can be adjusted to plants of different ages.

The careful investigation of this weevil during the past two or three years by the Division of Entomology has fully demonstrated the supreme importance of the cultural method of control, to which fact we gave special prominence in our first circular on this insect. There can be no question now that in the proper system of farming cotton a practically complete remedy for the weevil exists. In the first place, it has been established beyond question that the conditions of cultivation which make volunteer growth possible also makes the continuance of the weevil inevitable. Of first importance is the early removal of the old cotton in the fall, preferably in November or earlier. This can be done by throwing out the old plants with a plow, root and all, and afterwards raking them together and burning them. This treatment should be followed, as promptly as may be, by deep plowing, say to a depth of 6 or 8 inches. This leaves the field comparatively clean of old cotton stalks, facilitates thorough cultivation the following year, and, at the same time, collects and destroys all of the weevil larvæ and pupæ in the cotton at the time, and also most of the adults. The escaping beetles will be buried by deep plowing, and will not again reach the surface. Few, if any, of them will succeed in hibernating in the absence of cotton stalks and other ordinary rubbish in which they winter. Fields treated in this way have given a practical demonstration of the usefulness of the method.

The greatest danger from the weevil is due to the presence of volunteer cotton, which means early food for the weevils in the spring and abundant means for their overwintering, and the effort made to retain volunteer and get early cotton, or the "first bale," is a very serious menace to cotton culture within the weevil district.

This cultural method, if generally practiced, will undoubtedly prove a perfect remedy for upland cotton, and will vastly reduce weevil damage in the lowlands, where the weevil is more apt to winter, perhaps in adjoining woods or roadside vegetation. The early removal of cotton by the means suggested is especially advised whenever the presence of the weevil shows that the picking of a top crop is problematical. In such instances it would be well to uproot and destroy cotton stalks in September or October, as would have been thoroughly feasible for much of the upland cotton in 1896. If this cultural method can be enforced, either by State legislation or by the cooperation and insistence on the part of landowners that their renters shall carry out the system outlined, the weevil difficulty can undoubtedly in very large measure be overcome.

In connection with the system of fall treatment of the cotton, constant and thorough cultivation of the growing crop is of considerable value, and is also what should be done to insure a good yield. With a crossbar to brush the plants many of the blossoms and squares containing weevils will be jarred to the ground and buried, together with those already on the ground, in moist soil, and a large percentage of the material will rot before the contained insects have developed.

OTHER COTTON INSECTS.

The reports of the Entomological Commission and the report by Comstock, published by this Department in 1879, treated only incidentally of the other insects which affect the cotton plant. The main endeavor in the large investigation was to cover the ground of the cotton worm; even the bollworm was considered as of minor importance. In fact, the only consideration given to the subject of the other insect enemies of this crop has been the description of a few species by Glover in several of the earlier reports of this Department, and in his copper-engraved folio entitled "Cotton insects." The writer has compiled a list of the insects found in the cotton fields and which are mentioned in the reports of Glover, in the bulletins and special reports of the Division of Entomology, in Bulletin 3 and the Fourth Report of the Entomological Commission, together with those mentioned in the notebooks of the Division of Entomology and of the United States Entomological Commission, and has added to this list the species mentioned in the monthly reports of the statistical division of this Department, those collected by Ashmead in Mississippi in the summer of 1893, those collected by Barnard in Louisiana in 1879–80, and those collected by Mally in Mississippi and Louisiana in 1890–91, together with a few collected by Banks in Louisiana in 1891.

The list as a whole comprises about 465 species. A small proportion of these, however, can be considered as injurious to the cotton plant and still smaller numbers have attracted the attention of cotton planters through their injuries to the crop. Many of them are parasitic or predaceous upon species which damage the plant to a greater or less extent, while many others are accidental visitors to the cotton fields, and might have been collected as readily in fields of corn or cowpeas in the same general locality. Some little consideration, however, may be given here to certain species which occasionally accomplish considerable damage.

CUTWORMS.

The first insect which attacks the young cotton plant in the spring is liable to be a cutworm. Soon after the young plants come up, and often after they are fairly well grown, they are liable to be cut off at the surface of the ground by one of these caterpillars, all of which have the habit of hiding beneath the surface of the ground by day and coming out to work at night. The work of these insects in general was frequently mentioned by Glover, but the species were not determined. In Riley's report as Entomologist to this Department for 1884 the subject of cutworms in cabbage fields received careful treatment, and the statement was incidentally made upon page 291 that the granulated cutworm (the larva of *Feltia annexa* Treitschke) is probably the most common of the species collectively designated by Glover as the "cotton cutworm." This species is illustrated herewith. A number of other species, how-

ever, are undoubtedly concerned in this damage. The larvæ of *Feltia malefida*, *Noctua c-nigrum*, *Agrotis ypsilon*, and *Plusia rogationis* have been found to have similar habits.

Since the discovery of the poisoned-trap system, there is no reason why land should be allowed to be infested by cutworms year after year. Dr. A. Oemler, of Wilmington Island, Georgia, the author of the excellent little book entitled "Truck farming in the South," had been for some years in the habit of scattering bunches of grass through his fields, or placing here and there turnip or cabbage leaves, and collecting from time to time the cutworms which had gathered under them. At the suggestion of Professor Riley, in 1882 or 1883, he began poisoning these vegetable traps with paris green, which saved the trouble of examining them and killing the worms by hand. The method proved perfectly satisfactory, and has since been extensively used in all parts of the country. An innovation was later adopted by Prof. A. J. Cook, of Michigan, who poisoned a patch of grass with a broadcast sprayer, afterwards cutting the grass, loading it on a wagon, and pitching it with a fork in little bunches here and there through the field. Any early vegetation may be used in this way, and extensive fields can be economically rid of the worms before most crops show themselves above ground.

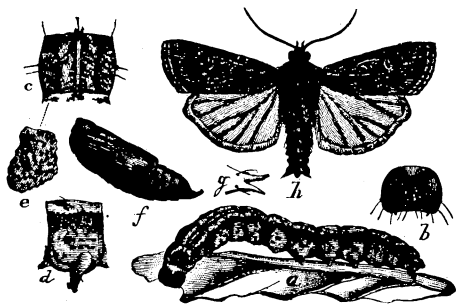

FIG. 12.—*Feltia annexa*: *a*, larva; *f*, pupa; *h*, moth—natural size (after Riley).

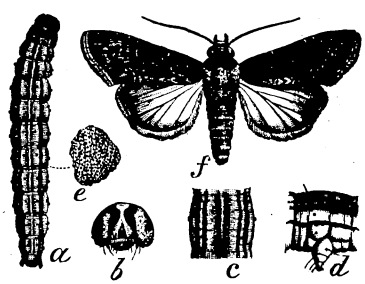

FIG. 13.—*Feltia malefida*: *a*, larva; *f*, moth—natural size (after Riley).

PLANT-LICE.

While the cotton plant is yet young and tender, the damage which plant-lice do by gathering upon the young shoots and tender leaves and curling and distorting them may be very considerable. The species engaged in this work is generally, if not always, *Aphis gossypii* Glover. Recent investigations by Mr. Pergande, of this Division, have shown that this insect is identical with the species which occurs commonly through the South, and the North, too, for that matter, upon melons and cucumbers, and which was described by Ashmead as *Aphis citrulli* and by Prof. S. A. Forbes as *Aphis cucumeris*. It has very many food plants, as has been shown by Pergande, and remedial work, except upon the crop which it is proposed to protect, is practically out of the question. In other words, there is no single

alternate perennial food plant, as in the case of the hop aphis, upon which the insect may be destroyed during the earlier or later portion of the year. As the cotton plant grows larger and stronger the work of the cotton aphis becomes of no importance, partly through the hardier condition of the plant, but also through the fact that the many natural enemies of the lice increase to such numbers as nearly to annihilate them. There will seldom be, therefore, any necessity for the application of remedies; and, indeed, as nothing can be done except to spray with a dilute kerosene-soap emulsion or a resin wash, it is a question whether it will not pay the cotton grower much better to replant the damaged spots.

LEAF-FEEDING CATERPILLARS.

There are many Lepidopterous larvæ which feed upon the leaves of the cotton plant; few of them, however, are confined to the cotton plant for food. One of the species most commonly noticed, *Cacœcia rosaceana*, is known from its work as the leaf roller—a title under which another species, *Dichelia sulphureana*, may also be included. Both species are general feeders and are found in various parts of the country, the former upon apple, rose, peach, cherry, birch, clover, honeysuckle, bean, strawberry, and other plants, and the latter upon clover and grass. The larvæ of the former, in addition to folding the leaves of cotton and feeding within the roll, sometimes bore into the young bolls (Mally), but this method of damage is rare.

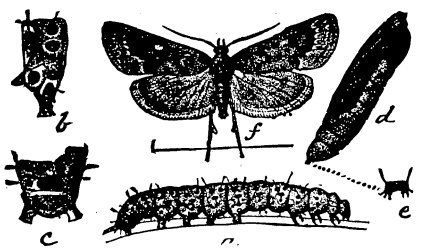

FIG. 14.—*Pyrausta rantalis*: *a*, larva, enlarged; *b*, side view of abdominal segment of same; *c*, dorsal view of anal segment, still more enlarged; *d*, pupa; *f*, moth, enlarged (after Riley).

Several of the larger Bombycids also feed in the larval state upon cotton. Among these we may mention the large royal horned caterpillar, *Citheronia regalis*, sometimes known as the "hickory horned devil," a very large green caterpillar with long recurved red horns; the large green, somewhat hairy larva of the Imperial moth (*Eacles imperialis*), and the large spiny larva of *Ecpantheria scribonia*, as well as the yellow-green stinging caterpillar of the Io moth (*Hyperchiria io*), and the "woolly bear" caterpillars of *Leucarctia acræa*, *Spilosoma virginica*, and *Arctia phyllira*. The last-named species seems to possess greater capabilities for damage than any of the others, and H. E. Weed has reported a case in which several acres were entirely defoliated by it about the middle of June, in Mississippi.

Two bagworms are also occasionally found feeding upon cotton leaves, constructing their cases from fragments of the leaves sewed together with silk. These are the common bagworm of the North, *Thyridopteryx ephemeræformis*, and Abbot's bagworm (*Oiketicus abbotii*), a Southern species.

Late in the fall the common grass worm, or fall army worm (larva of *Laphygma frugiperda*), ranges through the cotton fields, feeding upon volunteer grass, and occasionally ragging the leaves of the cotton plant. Two allied native species, viz, *Prodenia commelinæ* and *P. flavimedia*, also occasionally feed upon cotton leaves.

The larva of the handsome little butterfly known as *Thecla pœas* feeds upon the leaves and occasionally bores into the bolls.

The larvæ of *Acronycta oblinita* and *Anisota senatoria* have also been found by Mally engaged in this work.

In a limited section of the country, namely, in portions of Texas and the Indian Territory, the so-called garden webworm, *Pyrausta rantalis*, occasionally does some damage to the cotton crop, as it did in 1885. Feeding principally upon corn, its injury to cotton is incidental, yet it may, in the early part of the season particularly, do some little damage to this crop. Its preference for corn is noticed mainly when fields overrun with pigweed and careless weed (*Amarantus* spp.) are broken up for planting, and, in fact, these weeds seem to be its natural food. It will probably never do serious damage to cultivated crops, except where these weeds have been allowed to run wild for a season or so and are then plowed under and the land planted to some useful crop. The small green caterpillars feed upon the leaves, concealing themselves between them during the day and skeletonizing them at night.

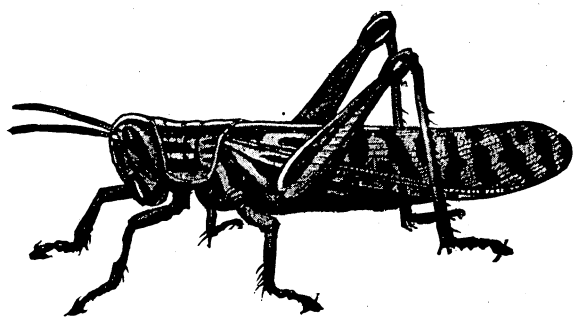

FIG. 15.—*Schistocerca americana:* adult female—natural size (from Insect Life).

The remedy for any or all of these leaf-feeding caterpillars, whenever one of them occasionally becomes so abundant as to threaten damage, as happened with the *Arctia phyllira* above mentioned, will be to spray with paris green, or dust it on dry, as for the cotton caterpillar.

OTHER INSECTS WHICH DAMAGE THE LEAVES.

Among the other insects which injure the foliage of the cotton plant, grasshoppers are the most prominent. Several species have this habit, and the list of cotton insects contains the names of fourteen which are found upon the plant. Here also the damage to cotton seems incidental; they feed by preference upon grass. The species which ordinarily cause the greatest alarm among cotton planters are the large American locust (*Schistocerca americana*) and the lubber grasshopper (*Brachystola magna*). The paris green treatment will again be effective here, but

when grasshoppers occur in considerable numbers, attracting them to a mash made of sweetened bran and arsenic will prevent leaf feeding to a great extent.

Many leaf hoppers and several leaf-feeding beetles have been found upon the cotton plant, but need not be particularly mentioned here. In many portions of Texas the leaves are frequently cut off by the so called leaf-cutting ant, *Œcodoma fervens*. One of the few practical remedies against this destructive insect, which damages fruit trees and other field crops as well as cotton, consists in tracing the ants to their nest (which is often an extremely difficult thing to do) and destroying them there by copious applications of kerosene or bisulphide of carbon. Another method, which has been practiced with some success by an intelligent Texan, is to spread a line of cyanide of potassium across the well-defined path by which the ants leave their nest; this kills very many, and deters the ants from taking the direction of the particular path thus obstructed.

INSECTS DAMAGING THE STALK.

Puncturing of the terminal portion of the stalk by plant bugs occasionally occurs, but is comparatively rare. There is but one borer in

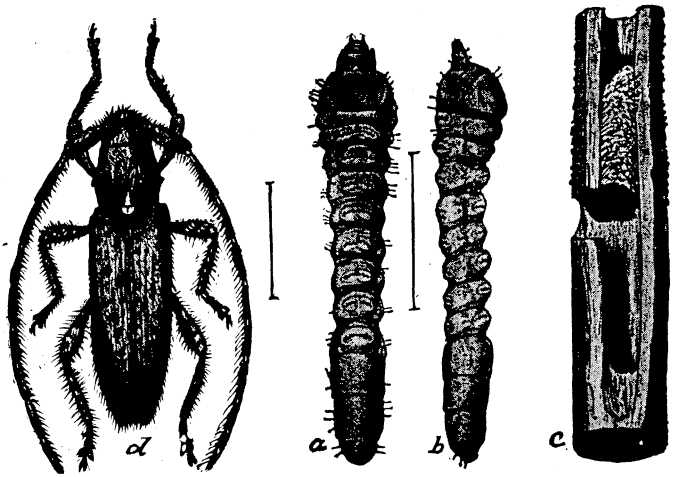

FIG. 16.—Cotton stalk borer (*Ataxia crypta*): *a*, larva from above; *b*, larva from side; *c*, tunneled cotton stalk showing exit hole; *d*, adult beetle—all enlarged except *c* (author's illustration).

the stalks of cotton, and that is the long-horned beetle known as *Ataxia crypta* (fig. 16). It is occasionally mistaken for an enemy to the plant, but investigation has shown that it lays its eggs upon and its larvæ bore into only such stalks as have been damaged by some other cause, such as rust. It follows injury to the plant, therefore, rather than causes it.

INSECTS INJURING THE BOLL.

As in the case of the stalk borer just mentioned, numerous species of insects are found in damaged bolls which are the result, rather than the cause, of the damage. Several little Nitidulid beetles are found in

such injured bolls, and a number of other insects have been sent to the Division of Entomology of this Department from time to time with the statement that they threatened damage to the crop. Among these the larva of a little weevil, *Arœcerus fasciculatus*, deserves especial mention for the reason that it so closely resembles the larva of the Mexican cotton-boll weevil. In fact, the larvæ of both species are found living in the same boll. *Arœcerus fasci ulatus* is a cosmopolitan insect living in the pods of various plants, among others in those of the coffee plant in Brazil, but is never known to attack healthy plants. The perfect weevil is also among the various insects which are mistaken by the planters for the Mexican cotton-boll weevil, but its very short and blunt beak should at once distinguish it from the latter species. Aside from the true bollworm, several of the caterpillars found upon the plant will occasionally gnaw the bolls, but this gnawing is in general incidental to their work upon the leaves. One of these is a leaf roller, the larva of *Platynota sentana*, which attacks the forms and squares, much like the young bollworm, afterwards feeding upon the leaves. A congeneric species (*Platynota rostrana*) also bores into the young bolls. The reddish larva of a little Tineid moth belonging to a group mostly composed of leaf miners, and known as *Batrachedra rileyi*, is often found in the young bolls, and is generally believed by planters to act independently of bollworm damage. This statement, however, has not yet been satisfactorily substantiated so far as it refers to the bolls. In the young squares, however, the active little reddish larva of this Batrachedra is very often found as unquestionably an original inhabitant, and it undoubtedly frequently causes quite an extensive shedding of the squares. This, however, occurs only in the spring, at a time when there is a surplus of bloom and when many squares can be spared without great reduction of the crop. Later in the season the Batrachedra larva is found boring in the unopened flower heads of various weeds.

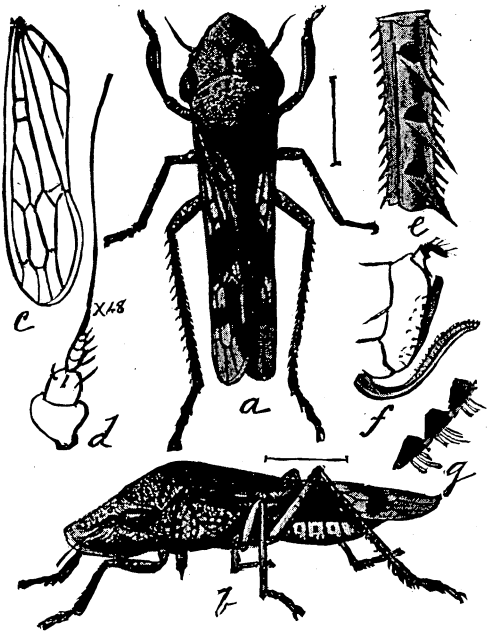

FIG. 17.—*Homalodisca coagulata: a*, adult female seen from above; *b*, same, side view; *c*, venation of fore wing, enlarged; *d*, antenna; *e*, section of hind tibia; *f*, female genitalia, still more enlarged; *g*, serrations of ovipositor, still more enlarged (from Insect Life).

There is a class of damage to the bolls which is known to planters as "sharpshooter work," which is mainly caused by the punctures of a leaf hopper known as *Homalodisca coagulata*. The insect is most abundant from the first of June on through the season. Prior to the first of June it seems to prefer the young growth and foliage of poplars and other trees which may grow in the immediate vicinity. Where sharpshooter work is prevalent in the cotton field, year after year, and the trees which harbor the insects can be found in the early part of the season, a single application of kerosene emulsion to the lower parts of such trees or scrub growth might be made to advantage in the month of May.

An insect which at one time did very considerable damage to cotton bolls, particularly those which were far advanced or had burst, is the red bug or cotton stainer, *Dysdercus suturellus*. This insect was never

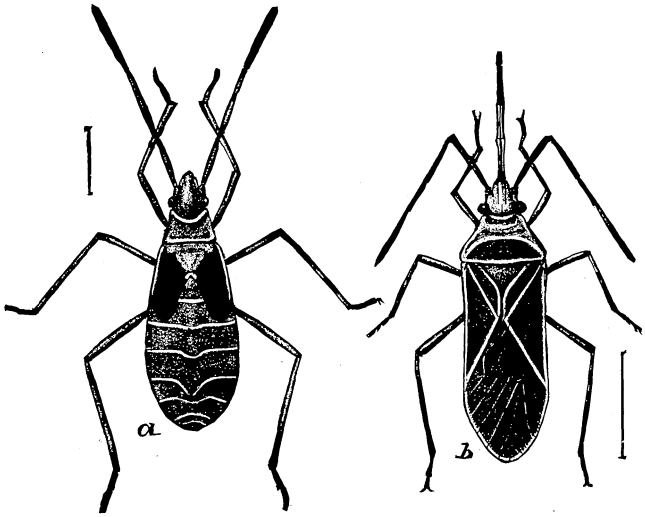

FIG. 18.—The red bug, or cotton stainer (*Dysdercus suturellus*): *a*, pupa; *b*, adult—enlarged (from Insect Life).

prevalent except in Florida, Georgia, and neighboring portions of South Carolina and Alabama. It is probably a West Indian species. Of late years, and more especially since cotton culture in Florida has given place to extensive orange culture, it has largely transferred its attention to the orange fruit. Earlier generations of this insect damaged the bolls by puncturing them and sucking the sap, causing them to become diminutive or abortive. Later, however, they entered open bolls, puncturing the seed and damaging the fiber by their yellowish excrement. These stains were indelible and greatly depreciated the value of the cotton in the market. The indelibility and beautiful color of the stains at one time suggested the use of the insects in making dyes. Experiments showed that the entire substance of the insect could be

converted into a rich orange-yellow dye, which could be readily fixed upon woolens or silks by the alum mordant liquor, and that an ochreous yellow lake could be made from them by precipitating the coloring matter with gelatinous alumina. There has been, however, no commercial adoption of the results of these experiments.

The best remedy against this species is suggested by the fact that in winter it will collect in numbers on piles of cotton seed, which can then be used as traps and the insects destroyed by the application of hot water.

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